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above it, for the reason which I gave before. These, however, are mere matters of detail, and I am glad to see that such a compensation is "perfectly successful."

It may be as well to mention, that "Baily's result for a detached one, viz. 0·41 sec.," mentioned by Dr. Robinson, does not mean a "detached escapement;" but what is more generally called a *free* pendulum, set vibrating without a clock, and observed as long as it will swing a considerable arc. The number of values of the barometric error which have now been mentioned proves the necessity of ascertaining it, by trial of the individual clock, before calculating the correction for it.

I had not seen the Westminster pendulum for some years until the other day, when I was asked to explain the clock to the members of the Horological Institute, and I find the arc is even larger than I stated from memory, and, as near as I could see, is 2° 45′; the very arc at which Baily calculated that the circular error ought to compensate the barometric (*Phil. Trans.* of 1832). This confirms the conclusion arrived at before from the rate of the clock during last year.

I have also been told by a very able clockmaker, Mr. Brock, of George Street, Portman Square, that he has often found so many clocks affected in the same direction at the same time, with no apparent cause, that he had come to the conclusion that they are affected by the electrical state of the atmosphere, as they certainly are sometimes by thunderstorms. That point is worth attending to by those who have the means of doing so, now that the electricity of the atmosphere is regularly observed.

On Mr. Denison's Compensation for the Barometric Error of Clocks. By the Rev. T. R. Robinson, D.D.

In Mr. Denison's paper on this subject there are two points which require a few words from me: one, his statement, "that it seems that it" (the compensation) "had been done in some way;" the other, "that I had found difficulty in calculating the adjustments for it."

If Mr. Denison will look at page xix. of the Introduction to the *Armagh Catalogue*, he will find a description of my compensation, and will see that his own differs from it only by the complex and inconvenient arrangement of his tubes.

There is no difficulty in calculating the diameter and position of the barometers which shall compensate a given pendulum; but there is much in making the working of that compensation perfect. This can only be done by applying the method of of minimum squares to a large number of rate observations, extending over periods which shall include the extreme annual range of temperature. Three unknown quantities must be determined;

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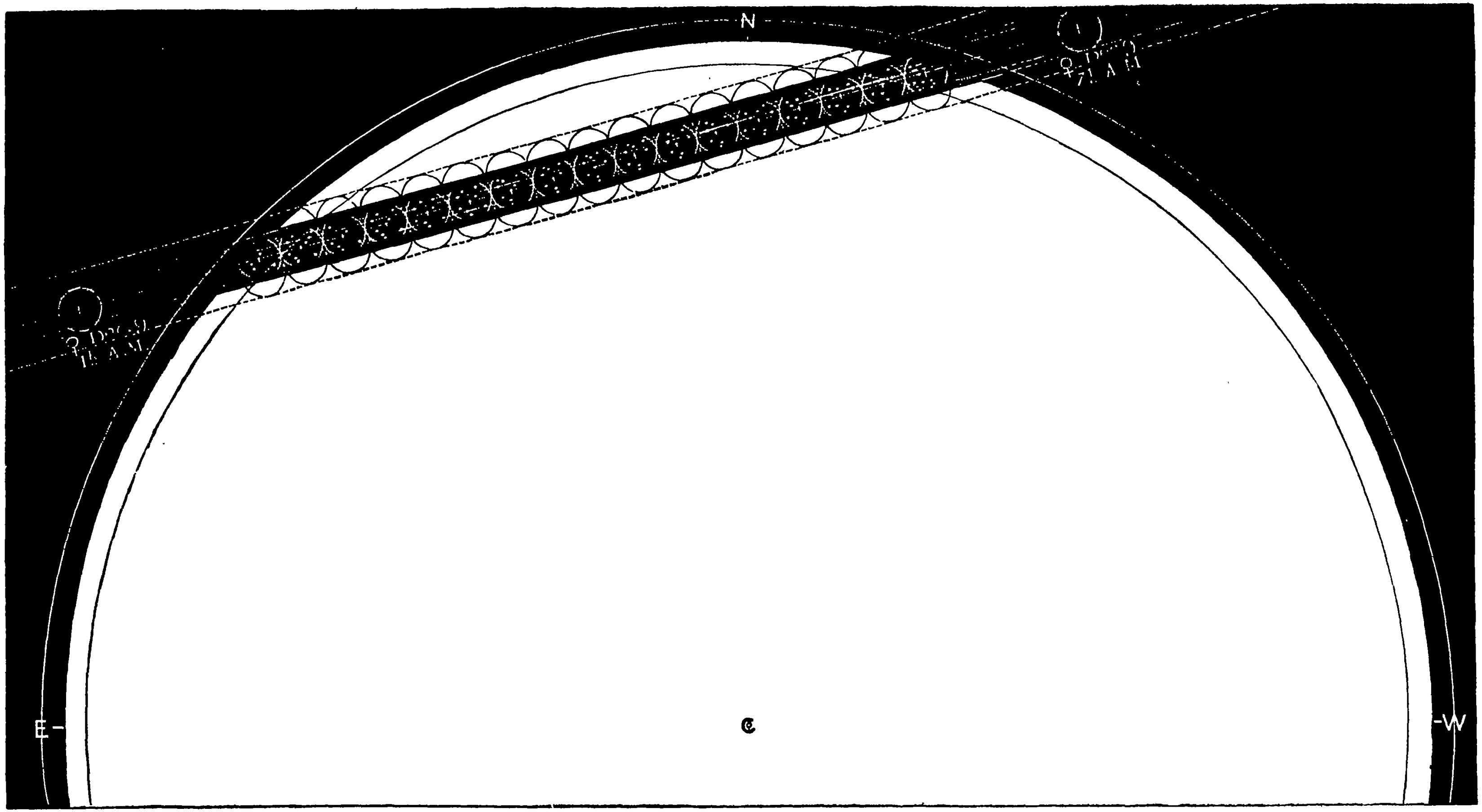

Fig. 3.—Illustrating the Transit of *Venus* across the Sun's Disk, on December 9, 1874.

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and the process must be repeated for every change of the barometer tube's position which involves also changes of rate and heat-compensation.

All this work is required with Mr. Denison's compensation precisely as with mine. It was seven years before I was satisfied with my work; and it was this experience which induced me to recommend, in preference to my own invention, the placing the pendulum in an atmosphere of hydrogen.

On the Barometric Error of Clocks. By R. Webster, Esq.

The paper of Mr. Carrington in the *Monthly Notice* for November, "On the rate of a Clock going in a Partial Vacuum," and the subsequent papers by Dr. Robinson and Mr. Denison in the January number, have led me to investigate the same subject.

Since May 1872, I have had a telegraphic wire direct from the Royal Observatory, conveying hourly signals of Greenwich mean-time, by striking on a bell. In the same room with this telegraphic apparatus, I have several astronomical clocks with gravity and dead-beat escapements. I have selected the best of these, the maximum deviation of which from Greenwich mean-time, since November 11th, 1872, to the present time, has not exceeded two seconds on each side of 0, and this I principally attribute to the barometric error. It has a dead-beat escapement, with jewelled pallets, jewelled escape holes, pinions of sixteen, mercurial pendulum with iron jar, and the arc of vibration is 1° 58′ on each side of 0.

On February 18th, a dense atmospheric wave passed over London, and the barometer indicated 30·76. A daily fall occurred until the 26th, when it marked 29·00, giving a range of 1·76 inches in eight days.

The following is the rate of the clock, the height of the barometer and the thermometer:

	Sec.	Bar.	Ther.
Feb. 17	− 0·1	30·22	46
18	− 0·3	30·76	47
25	0·0	29·68	44
26	+ 0·2	29·00	49

By taking the difference of rate on the 18th and 26th, the days of maximum and minimum of barometer we have

$$\frac{0·50}{1·76} = 0·28$$

Comparing the 17th and 18th,

$$\frac{0·20}{0·54} = 0·37,$$

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